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Research Article

Lower Skeletal Muscle Mass at Admission Independently Predicts Falls and Mortality 3 Months Post-discharge in Hospitalized Older Patients

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Abstract

Background: Approximately 10% of older adults are annually admitted to a hospital. Hospitalization is associated with a higher risk of falls and mortality after discharge. This study aimed to identify predictors at admission for falls and mortality 3 months post-discharge in hospitalized older patients.
Methods: The Evaluation of Muscle parameters in a Prospective cohort of Older patients at clinical Wards Exploring Relations with bed rest and malnutrition (EMPOWER) study is an observational, prospective longitudinal inception cohort of 378 patients aged 70 years and older who were subsequently admitted to a tertiary hospital (the Netherlands). Potential predictors for falls and mortality 3 months post-discharge were tested using univariate and multivariate logistic regression analyses and included the following domains: demographic (age, sex, living independently), lifestyle (alcohol, smoking), nutrition (SNAQ score), muscle mass (absolute, relative), physical function (handgrip strength, Katz ADL score), cognition (six-item cognitive impairment test score), and disease (medications, diseases).
Results: The mean age was 79.6 years (standard deviation 6.23) and 50% were male. Within 3 months post-discharge, 19% reported a fall and 13% deceased. Univariate predictors for falls were higher age, lower absolute muscle mass and higher six-item cognitive impairment test score. Lower absolute muscle mass independently predicted falls post-discharge (multivariate). Univariate predictors for mortality were higher age, male sex, no current alcohol use, higher SNAQ score, lower absolute and higher relative muscle mass, higher Katz ADL score and higher number of diseases. Male sex, higher SNAQ score, and lower absolute muscle mass independently predicted mortality post-discharge (multivariate).
Conclusions: In hospitalized older adults, muscle mass should be measured to predict future outcome. Future intervention studies should investigate if increasing muscle mass prevent short-term falls and mortality.

Keywords: Hospitalization, Outcome assessment, Muscular atrophy

Hospitalization in older individuals is associated with adverse health outcomes such as increased risk of falls and mortality after discharge (1,2). Falls are a serious medical problem in older individuals leading to decreased physical function, severe injury, and morbidity (3,4). Falls rates have been reported to be specifically higher during the first weeks after discharge due to recent illness and decline of physical function during hospital stay (5). In the majority of cases, mortality is an unwarranted outcome of a disease trajectory after hospitalization and affects 35% of older individuals 1 year after hospital admission (6).

Tools predicting short-term falls and mortality post-discharge remain limited and are most often tailored to a specific group of patients based on their disease characteristics (6–10). Risk factors known to contribute to falls and mortality in hospitalized older patients include poor functional status, poor cognition, illness severity, comorbidities, and polypharmacy (11–13). Additionally, malnutrition and low health-related quality of life has also been attributed to a higher mortality rate 3 months post-discharge (14,15). Muscle mass and muscle strength have been shown to strongly predict adverse outcomes in cohorts of older individuals (16–20), but very limited data are available on its capacity predicting short-term outcome post-discharge in older patients (14).

The aim of this study was to identify predictors at admission for falls and mortality 3 months post-discharge in a cohort of hospitalized patients 70 years and older.

Methods

Study Design

The Evaluation of Muscle parameters in a Prospective cohort of Older patients at clinical Wards Exploring Relations with bed rest and malnutrition (EMPOWER) study is an observational, prospective, longitudinal inception cohort study which was conducted from April 2015 to December 2015 at the VU University Medical Center in Amsterdam, The Netherlands. In total, 838 patients aged 70 years or older who were admitted to either one of four clinical wards (acute admission, internal medicine, neurosurgery and orthopedics or traumatology) were considered eligible and subsequently screened for participation in EMPOWER. Patients had to sign informed consent to participate. Patients were excluded if: (i) their expected length of stay was less than 24 hours; (ii) they were nursed in isolation rooms; (iii) they were terminally ill; and (iv) they were not able to understand the Dutch language. A total of 378 patients were included in the EMPOWER study (14). Patients were assessed within 48 hours after admission (n = 378) and 3 months post-discharge by a telephone interview (n = 297). The study was approved by the medical ethics committee of the VU University Medical Center, Amsterdam, The Netherlands.

Domains Characteristics at Admission

Potential predictors for falls and mortality were grouped into seven domains: demographics, lifestyle, nutrition, physical function, muscle mass, cognition, and disease.

Demographics

Age and sex were collected from medical records and living situation during a bedside interview. Living independently (yes/no) was defined as living at home compared to living dependently in nursing homes and rehabilitation centers.

Lifestyle

Current alcohol use (yes/no) and current smoking (yes/no) were collected during a bedside interview.

Nutrition

Risk of malnutrition was measured using the Short Nutritional Assessment Questionnaire (SNAQ) with a score ranging from 0 to 7 points with higher scores indicating greater risk of malnutrition (21).

Physical Function

Handgrip strength (HGS) was measured using a Jamar Hydraulic Handheld Dynamometer (Sammons Preston, Inc. Bolingbrook, IL). Patients were asked to sit in an upright position with shoulders adducted and the elbow unsupported and flexed at 90 degrees. If patients were unable to sit, HGS was measured with the bed at an angle of 30 degrees, elbows unsupported and flexed at 90 degrees. Patients were asked to squeeze maximally twice for each hand, encouraged by the trained assessor. The maximum score of the four trials was used for the analyses and expressed in kilograms (22). Activities of daily living (ADL) dependency was assessed using the Katz score, ranging from 0 to 6 points, a higher score meaning greater dependency (23).

Muscle Mass

Weight was measured on a weighing chair. If patients were unable to get out of bed, an estimate was obtained from the patient or a relative. Height was estimated using knee-height and the Longitudinal Aging Study Amsterdam formula (LASA): female: height (cm) = 68.74 − (0.16 × age) + (2.07 × knee-height in cm), male: height (cm) = 74.48 − (0.15 × age) + (2.03 × knee-height in cm) (24). Direct segmental multi-frequency bioelectrical impedance analysis (InBody S10, Biospace Co., Ltd, Seoul) was used to assess muscle mass (25), expressed as: (i) skeletal muscle mass (SMM) in kilograms; (ii) SMM as percentage of body weight (26); (iii) skeletal muscle index (SMI: SMM divided by height squared) in kg/m^2 (19); and (iv) appendicular lean mass (ALM) in kilograms. All muscle mass variables were analyzed as continuous variables. SMM in kilograms, SMI, and ALM in kilograms were considered absolute muscle mass, SMM as a percentage was considered relative muscle mass. Direct segmental multi-frequency bioelectrical impedance analysis measurements were not performed in case of an implantable cardioverter defibrillator or other implanted devices (n = 29) or if it was impossible to position the electrodes on the middle fingers, thumbs and ankles (n = 28).

Cognition

Cognition was assessed with the six-item cognitive impairment test, ranging from 0 to 28 points, a higher score indicating lower cognitive functioning (27).

Disease

Medical records were used to collect data on the number of medications and number of diseases. The following diseases contributed to the number: stroke, chronic obstructive pulmonary disease, chronic kidney failure, hypertension, myocardial infarction, diabetes mellitus, cancer, thyroid disease, Parkinson's disease, arthrosis, rheumatoid arthritis, osteoporosis, and dementia.

Falls and Mortality 3 Months Post-discharge

Falls 3 months post-discharge was assessed by a telephone interview and defined as at least one fall within 3 months post-discharge. All-cause mortality was extracted from the hospital data system 3 months post-discharge and included in-hospital deaths.

Statistical Analyses

Continuous variables with a normal distribution were presented as mean ± standard deviation (*SD*) and a skewed distribution as median and interquartile range (IQR). Categorical and binomial variables were presented as numbers (*n*) and percentage (%). Patient characteristics at hospital admission were compared between patients who reported at least one fall 3 months post-discharge with patients who reported no fall, and between patients who were deceased 3 months post-discharge with patients who were alive. Statistical differences were analyzed using Paired Samples *t* test (continuous variables with normal distribution), Mann–Whitney U test (continuous variables with skewed distribution) and Chi-square or Fisher's Exact Test (dichotomous variables).

Univariate logistic regression analysis was performed to analyze associations between the independent variables (variables within the health domains) at admission and dependent variables (falls and mortality) 3 months post-discharge. Multivariate logistic regression analysis was performed using the significant variables ($p < .20$) from the univariate logistic regression analysis. Due to the multicollinearity within the muscle mass domain, the variable with the lowest *p*-value was chosen for the multivariate analysis. Significance for the multivariate logistic regression analysis was set at $p < .05$. Results of the logistic regression analysis were presented as odds ratios (OR and 95% confidence intervals [CI]). Patients were selected to be included for the univariate and multivariate if data were available on all potential predictors and falls/mortality 3 months post discharge (222 patients for the falls analysis and 291 patients for the mortality analysis). Statistical analyses were performed using the Statistical Package for the Social Sciences (IBM SPSS Statistics for Windows, Version 24.0 Armonk, NY, IBM Corp).

Results

Figure 1 shows the flowchart of patient screening, inclusion, follow-up, and patients included for the present analysis. The falls analysis included 222 patients and the mortality analysis 291 patients. Table 1 shows the descriptive characteristics of patients at hospital admission. The mean age was 79.4 ± 5.99 years and 79.6 ± 6.23 years, and 49.1% and 50.2% of the patients were male

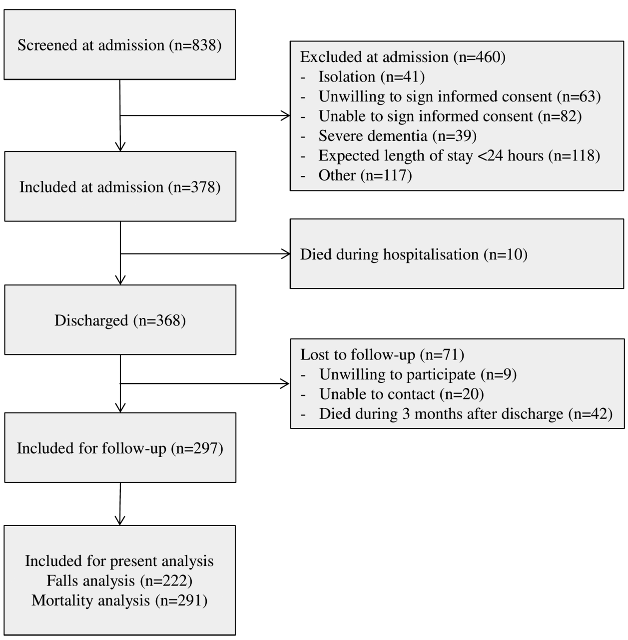

Figure 1. Flowchart of patient screening, inclusion and follow-up (adapted figure from Verlaan et al. (14)).

for the falls and mortality subgroup respectively. Three months post-discharge, 19.4% reported at least one fall and 12.7% deceased in the period from hospital admission to 3 months post-discharge. Patients that reported at least one fall 3 months post-discharge had significantly higher SNAQ score, lower absolute SMM, lower SMI and higher six-item cognitive impairment test score at admission compared to patients with no fall. Patients who were deceased 3 months post-discharge were significantly more often male, had higher SNAQ score, lower SMI and higher number of diseases at admission compared to patients who were alive.

Predictors for Falls 3 Months Post-discharge

Table 2 shows the univariate and multivariate analysis of the domain characteristics at admission with falls 3 months post-discharge. Univariate predictors ($p < .20$) for falls were a higher age, lower absolute SMM, SMI and ALM, and higher six-item cognitive impairment test score. SMI had the lowest *p*-value predicting falls within the muscle mass domain. Lower SMI was the only independent significant predictor for falls in the multivariate analysis.

Predictors for Mortality 3 Months Post-discharge

Table 3 shows the univariate and multivariate analysis of the domain characteristics at admission with mortality 3 months post-discharge. Univariate predictors for mortality were higher age, male sex, no current alcohol use, higher SNAQ score, lower absolute SMM, higher relative SMM, lower SMI, higher Katz ADL score, and higher number of diseases. SMI had the lowest *p*-value predicting mortality within the muscle mass domain. Independent significant predictors for mortality 3 months post-discharge were male sex, higher SNAQ score and lower SMI.

Discussion

A lower absolute muscle mass, represented by SMI, was found to be an independent predictor for falls while male sex, a higher SNAQ score and lower SMI were independent predictors for mortality 3 months post-discharge.

The finding that muscle mass, represented by SMI, was one of the most significant independent predictor for falls is in agreement with recent meta-analyses showing an association of sarcopenia with falls, fractures, and mortality in diverse populations of older individuals (28,29). Despite the scarce evidence of muscle mass as predictor of adverse outcomes in hospitalized patients, the strong association across different cohort settings underlines the potential generalizability of pathophysiological mechanisms. Growing evidence highlights the clear relationship between low muscle mass and morbidity, such as osteoporosis and frailty, and the association with outcomes after surgical or pharmacological interventions (30). This is of upmost importance as muscle measures are sensitive to change during hospitalization due to prolonged bedrest (31,32). The appealing trait of skeletal muscle is its capacity to be modifiable in volume by nutritional and exercise interventions (33). Therefore, lower muscle mass as a risk factor for adverse outcomes is potentially reversible, which differentiates muscle mass from most other non-modifiable risk factors, such as age, cognition and the majority of chronic diseases. However, it is yet unknown if increasing muscle mass will subsequently lead to a reduction in adverse outcomes after hospitalization. Furthermore, barriers of effective interventions such as patients' engagement in physical exercise have to be overcome (34,35).

Table 1. Patient Characteristics at Hospital Admission

	Falls Subgroup			Mortality Subgroup		
	Total	Falls	No falls	Total	Deceased	Alive
	n = 222	*n* = 43	*n* = 179	*n* = 291	*n* = 37	*n* = 254
Demographics						
Age, years, mean (*SD*)	79.4 (5.99)	80.5 (5.97)	79.1 (5.98)	79.6 (6.23)	80.8 (7.48)	79.4 (6.03)
Sex, male	109 (49.1)	22 (51.2)	87 (48.6)	146 (50.2)	26 (70.3)*	120 (47.2)*
Living independently	203 (91.4)	39 (90.7)	164 (91.6)	260 (89.3)	33 (89.2)	227 (89.4)
Lifestyle						
Current alcohol use	97 (43.7)	17 (39.5)	80 (44.7)	120 (41.2)	11 (29.7)	109 (42.9)
Current smoking	21 (9.5)	4 (9.3)	17 (9.5)	30 (10.3)	4 (10.8)	26 (10.2)
Nutrition						
SNAQ total score, median [IQR]	0 [0–2]	1 [0–2]*	0 [0–2]*	1 [0–3]	3 [1–6]*	0 [0–2]*
Muscle mass						
SMM, kg, mean (*SD*)	26.9 (6.23)	24.9 (4.78)*	27.4 (6.46)*	26.3 (6.02)	25.0 (5.66)	26.5 (6.06)
SMM, %, mean (*SD*)	36.4 (6.02)	35.8 (6.38)	36.6 (5.94)	36.5 (5.60)	37.9 (5.73)	36.2 (6.01)
SMI, kg/m^2, mean (*SD*)	9.36 (1.46)	8.76 (1.36)*	9.51 (1.46)*	9.20 (1.47)	8.60 (1.53)*	9.29 (1.44)*
ALM, kg, mean (*SD*)	20.7 (5.74)	19.2 (4.34)	21.1 (5.99)	20.3 (5.56)	19.6 (5.31)	20.4 (5.59)
Physical function						
Handgrip strength, kg, mean (*SD*)	21.8 (10.5)	20.0 (9.00)	22.2 (10.9)	21.0 (10.1)	21.2 (7.99)	21.0 (10.4)
Katz ADL score, median [IQR]	0 [0–3]	1 [0–3]	0 [0–3]	0 [0–3]	1 [0–4]	0 [0–3]
Cognition						
6-CIT score, median [IQR]	4 [0–8]	6 [2–12]*	4 [0–8]*	4 [0–8]	3 [0–10]	4 [0–8]
Disease						
Number of medications, median [IQR]	8 [6–11]	9 [7–11]	8 [5–12]	8 [6–11]	9 [7–12]	8 [6–11]
Number of diseases, median [IQR]	3 [2–5]	4 [2–5]	3 2–5]	2 [2-5]	4 [3–7]*	3 [2–5]*

Notes: 6-CIT = six-item cognitive impairment test; ADL = Activities of daily living; ALM = Appendicular lean mass; IQR = Interquartile range; *SD* = Standard deviation; SMI = Skeletal muscle index; SMM = Skeletal muscle mass; SNAQ = Short Nutritional Assessment Questionnaire. All variables are presented as *n* (%), unless otherwise indicated.

*Statistically significant different $p < .05$.

Table 2. Predictors for Falls 3 Months Post-discharge (*n* = 222)

	Univariate		Multivariate	
	OR (95% CI)	*p*-value	OR (95% CI)	*p*-value
Demographics				
Age, years	1.04 (0.99, 1.10)	.152*	1.00 (0.94, 1.07)	.964
Sex, male	1.11 (0.57, 2.16)	.763	-	
Living independently	0.89 (0.28, 2.84)	.846	-	
Lifestyle				
Current alcohol use	0.81 (0.41, 1.60)	.541	-	
Current smoking	0.98 (0.31, 3.07)	.969	-	
Nutrition				
SNAQ total score	1.11 (0.94, 1.32)	.205	-	
Muscle mass				
SMM, kg	0.93 (0.87, 0.99)	.021*	-	
SMM, %	0.98 (0.93, 1.04)	.466	-	
SMI, kg/m^2	0.68 (0.52, 0.88)	.003*	0.71 (0.54, 0.93)	.012*
ALM, kg	0.94 (0.88, 1.00)	.055*	-	
Physical function				
Handgrip strength, kg	0.98 (0.95, 1.01)	.221	-	
Katz ADL score	1.05 (0.88, 1.25)	.584	-	
Cognition				
6-CIT score	1.06 (1.01, 1.12)	.022*	1.05 (0.99, 1.11)	.108
Disease				
Number of medications	1.03 (0.95, 1.12)	.501	-	
Number of diseases	1.02 (0.88, 1.19)	.776	-	

Notes: 6-CIT = six-item cognitive impairment test; ADL = activities of daily living; ALM = appendicular lean mass; CI = confidence interval; OR = odds ratio; SMM = skeletal muscle mass; SMI = skeletal muscle index; SNAQ = Short Nutritional Assessment Questionnaire. Interpretation: OR is per one unit higher of the predictor, eg, per 1 year of age higher, the OR is 1.04 (95% CI 0.99–1.10) on experiencing at least one fall 3 months post-discharge. The dash indicates the predictor was not selected from the univariate analysis to be included in the multivariate analysis.

*$p < .20$ in univariate analysis, *$p < .05$ in multivariate analysis.

Table 3. Predictors for Mortality 3 Months Post-discharge (n = 291)

	Univariate		Multivariate	
	OR (95% CI)	*p*-value	OR (95% CI)	*p*-value
Demographics				
Age, years	1.04 (0.98, 1.10)	.180*	1.02 (0.96, 1.09)	.567
Sex, male	2.64 (1.25, 5.57)	.011*	3.79 (1.60, 8.98)	.002*
Living independently	0.98 (0.32, 2.98)	.973	-	
Lifestyle				
Current alcohol use	0.56 (0.67, 1.19)	.132*	0.71 (0.30, 1.64)	.418
Current smoking	1.06 (0.35, 3.24)	.914	-	
Nutrition				
SNAQ total score	1.39 (1.20, 1.61)	<.001*	1.30 (1.11, 1.53)	.001*
Muscle mass				
SMM, kg	0.96 (0.90, 1.02)	.168*	-	
SMM, %	1.05 (0.99, 1.11)	.111*	-	
SMI, kg/m^2	0.70 (0.54, 0.91)	.008*	0.67 (0.49, 0.91)	.012*
ALM, kg	0.97 (0.91, 1.04)	.413	-	
Physical function				
Handgrip strength, kg	1.00 (0.97, 1.04)	.898	-	
Katz ADL score	1.16 (0.98, 1.37)	.093*	1.00 (0.82, 1.23)	.986
Cognition				
6-CIT score	1.01 (0.96, 1.07)	.671	-	
Disease				
Number of medications	1.05 (0.97, 1.15)	.218	-	
Number of diseases	1.19 (1.04, 1.37)	.015*	1.14 (0.97, 1.34)	.122

Notes: 6-CIT = six-item cognitive impairment test; ADL = activities of daily living; ALM = appendicular lean mass; CI = confidence interval; OR = odds ratio; SMM = skeletal muscle mass; SMI = skeletal muscle index; SNAQ = Short Nutritional Assessment Questionnaire. Interpretation: OR is per one unit higher of the predictor, eg, per 1 year of age higher, the OR is 1.04 (95% CI 0.98–1.10) on experiencing at least one fall 3 months post-discharge. The dash indicates the predictor was not selected from the univariate analysis to be included in the multivariate analysis.

*p < .20 in univariate analysis, *p < .05 in multivariate analysis.

Additional to SMI, multiple other factors of various domains were independently predictive for mortality 3 months post-discharge. Male sex is a risk factor for mortality across all age ranges (36). In line with our finding, another observational longitudinal study of inpatients also highlighted sex differences (37), most likely due to sex differences in disease burden (36).

Risk of malnutrition, assessed by the SNAQ, was positively associated with mortality 3 months post-discharge. This finding is concurrent with a study showing that hospitalized older patients who were at risk of malnutrition or who were malnourished were more likely to die in the hospital compared to those well-nourished (38). Furthermore, a high risk of malnutrition has been found to be associated with lower muscle mass and mortality in the same EMPOWER cohort (14,39).

Strengths/Limitations

To the best of our knowledge, this is the first study investigating several characteristics from different domains at admission with both falls and mortality 3 months post-discharge. The design being an inception cohort minimized selection bias of the study sample. The data for falls 3 months post-discharge were collected via telephone interviews, which could be prone to (recall) bias. Death (n = 42) and patients lost of follow up (n = 29) may have introduced bias of the study sample. Furthermore, body composition measurements may have been influenced by the hydration status affecting the ratio of muscle mass/fat mass. As the follow-up was performed using a phone call, the data collected post-discharge was limited and therefore lacks information such as medication use, social support, and healthcare consumption.

Conclusion

In hospitalized older adults, muscle mass represented by SMI was an important independent predictor for both falls and mortality 3 months post-discharge. Male sex and a higher risk of malnutrition were also significant predictors for mortality. Risk factor detection should be an essential part of a hospital stay and post-discharge policies should be established to prevent falls and mortality post-discharge. Muscle mass, however, is infrequently measured in regular clinical care (40) and further research should focus on the feasibility measuring muscle mass in routine clinical inpatient settings and interventions improving muscle mass as a modifiable risk factor eventually reducing falls and mortality after hospital stay.

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Conflict of Interest

None declared.

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